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# High-resolution live imaging of plant growth in near physiological bright conditions using light sheet fluorescence microscopy.

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## Abstract

Most plant growth occurs post-embryonically and is characterized by the constant and iterative formation of new organs. Non-invasive time-resolved imaging of intact, fully functional organisms allows studies of the dynamics involved in shaping complex organisms. Conventional and confocal fluorescence microscopy suffer from limitations when whole living organisms are imaged at single-cell resolution. We applied light sheet-based fluorescence microscopy to overcome these limitations and study the dynamics of plant growth. We designed a special imaging chamber in which the plant is maintained vertically under controlled illumination with its leaves in the air and its root in the medium. We show that minimally invasive, multi-color, three-dimensional imaging of live Arabidopsis thaliana samples can be achieved at organ, cellular and subcellular scales over periods of time ranging from seconds to days with minimal damage to the sample. We illustrate the capabilities of the method by recording the growth of primary root tips and lateral root primordia over several hours. This allowed us to quantify the contribution of cell elongation to the early morphogenesis of lateral root primordia and uncover the diurnal growth rhythm of lateral roots. We demonstrate the applicability of our approach at varying spatial and temporal scales by following the division of plant cells as well as the movement of single endosomes in live growing root samples. This multi-dimensional approach will have an important impact on plant developmental and cell biology and paves the way to a truly quantitative description of growth processes at several scales.



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